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# Geochemical Characterization and Geochemically Appropriate Levels for Soil Recovery Facilities

## Geological Survey Ireland Report
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Geological Survey Ireland is a division of the Department of Communications, Climate Action & Environment

# Geological Survey Ireland

Founded in 1845, Geological Survey Ireland is Ireland's public earth science knowledge centre and is a division of the Department of Communications, Climate Action and Environment. We are committed to providing free, open and accurate data and maps on Ireland's subsurface to landowners, the public, industry, and all other stakeholders, within Ireland and internationally. In addition, we act as a project partner in interpreting data and developing models and viewers to allow people to understand underground. We deal with a diverse array of topics including bedrock, groundwater, seabed mapping, natural disasters, and public health risks.

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# Disclaimer



# Reference

Glennon, M., Gallagher, V., Meehan, R. and Hodgson, J. (2020) *Geochemical Characterization and Geochemically Appropriate Levels for Soil Recovery Facilities.* Geological Survey Ireland report.

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# Executive summary

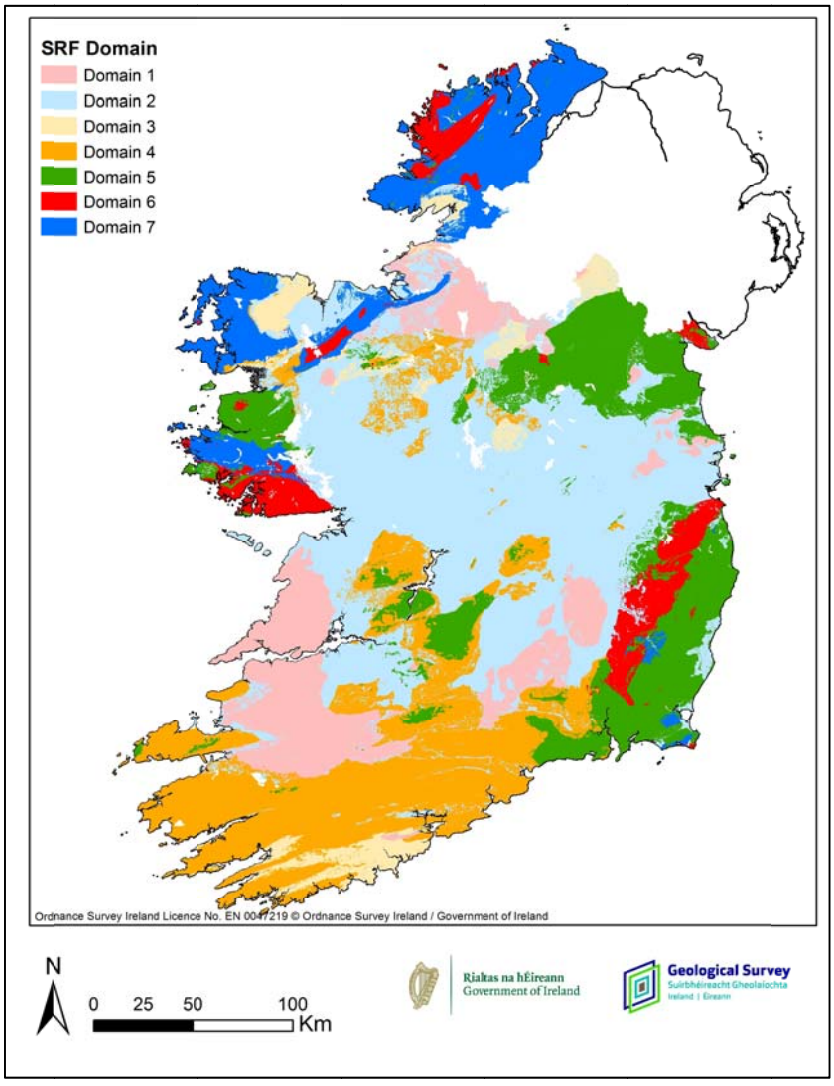
Geological Survey Ireland (GSI) has completed a project to inform the development of Geochemically Appropriate Levels (GALs) for Soil Recovery Facilities (SRFs) specifically in relation to metals and metalloids in uncontaminated soil and stone. A draft guidance document published by the EPA in December 2017 proposed acceptable limits for levels of chemical substances, including heavy metals and a range of organic compounds, in uncontaminated subsoil and stone to be accepted by waste-licensed SRFs (EPA, 2017). A number of submissions made to the EPA raised concerns that the proposed levels for metals were not practicable given a high degree of variation in natural metal contents of Irish subsoils.

The EPA approached GSI to assist in establishing an approach to setting appropriate trigger levels for metals for acceptance of uncontaminated soil and stone at SRFs, drawing on its expertise in the geochemistry and physical properties of natural geological materials. In response, GSI has considered the problem using the source-pathway-receptor conceptual framework, an established framework for modelling environmental risk. The placement of externally-sourced inappropriate material at SRFs poses a potential source of chemical contamination. In consultation with the EPA, the approach taken by GSI was to assume that soil and stone of a similar geochemical nature to that in the vicinity of a particular SRF can be admitted to the site with minimal risk to receptors. In terms of the source-pathway-receptor conceptual framework, this approach aims to prevent a source being introduced to the SRF and to prevent the chemical load on the receptor (down–gradient aquifer) from newly placed material exceeding the load from the original soil.

In order to understand field-scale natural geochemical variability, GSI undertook a geochemical investigation at two representative SRFs; a limestone quarry in Co. Dublin and a sand and gravel pit in Co. Kildare. Twelve boreholes were drilled using a cable percussion rig to a nominal depth of 10m within a 500m radius of each site; soils were sampled at approximately 1m intervals down-hole. 'Tellus' topsoil samples were also taken at each drilling location with a hand-auger at 0.05–0.20 m and 0.35–0.50 m depths. A total of 175 topsoil and subsoil samples were collected at the sites and analysed by ICP-MS for arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn) and separately for mercury (Hg), in both cases following *aqua regia* digestion. Particle size analysis was undertaken on a subset of 96 samples. The geochemical results were analysed within and between subsoil units, as well as down-hole and in relation to soil texture. Conceptual site

models were developed from borehole logs. Results indicate that the composition of topsoils and subsoils around the SRFs are comparable. Subsoils are distinguished by several upper outliers, some with quite high concentrations of certain elements. These outliers skew the data distribution but do not affect the conclusion that topsoils and subsoils share a broadly similar geochemistry. These data support the use of topsoil data as a proxy for subsoil data, in the absence of baseline subsoil geochemical data.

GSI also undertook a geochemical domain-setting exercise, which divided the country into zones or domains based on similar geochemical signature. This was undertaken by dividing the National Soil Database (NSDB) into domains based on mapped subsoil type and bedrock type. This resulted in seven geochemical domains. Each domain is associated with a range of geochemical data, from which the 98$^{th}$ percentile level has been determined and set as a GAL for that domain.



The calculated GALs show wide variation among the seven domains and are generally higher than the trigger values proposed in the EPA's (2017) draft guidelines (below). The latter is to be expected given the use of the 98$^{th}$ percentile rather the 90$^{th}$ percentile of the NSDB used in the draft guidelines. However, this accounts for only some of the observed variation and the recasting of the NSDB in the context of geological domains has led to significant changes for some calculated GALs, with notably high values for As in Domain 6, Cd in Domain 2 and Hg in both Domain 3 and Domain 6.

| Domain | n | As | Cd | Cr | Cu | Hg | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|
| **Domain 1** | 166 | 15.6 | 1.50 | 85.9 | 51.2 | 0.254 | 47.8 | 48.3 | 137 |
| **Domain 2** | 431 | 24.9 | 3.28 | 83.9 | 63.5 | 0.360 | 61.9 | 86.1 | 197 |
| **Domain 3** | 55 | 38.1 | 1.60 | 79.2 | 56.9 | 0.457 | 54.4 | 81.3 | 237 |
| **Domain 4** | 278 | 32.3 | 0.97 | 86.2 | 80.4 | 0.285 | 50.3 | 91.4 | 155 |
| **Domain 5** | 205 | 41.5 | 1.42 | 122 | 77.6 | 0.302 | 65.7 | 109 | 224 |
| **Domain 6** | 64 | 85.8 | 2.38 | 90.0 | 40.0 | 0.527 | 28.2 | 108 | 168 |
| **Domain 7** | 111 | 30.9 | 0.542 | 96.0 | 83.1 | 0.262 | 35.7 | 61.1 | 122 |
| **NSDB 90$^{th}$ percentile (Draft guidelines)** | 1310 | 16 | 1.3 | 75 | 35 | 0.2 | 42 | 48 | 126 |
| **NSBD 98$^{th}$ (all) percentile** | 1310 | 33.6 | 2.28 | 99.9 | 65.1 | 0.299 | 58.8 | 86.9 | 183 |

**Calculated GALs (98$^{th}$ percentile) for defined geochemical domains. n = number of samples. Units are mg kg$^{-1}$**

We recommend that the EPA considers adopting GALs as trigger levels based on the 98$^{th}$ percentile of the NSDB data, based on geological domains. GALs should be periodically reviewed with improved availability of baseline soil geochemistry data in Ireland, specifically, when Tellus topsoil geochemical mapping is completed nationally (projected 2028). Ideally, the approach would benefit from a national baseline subsoil geochemistry mapping exercise. We also note that large quantities of subsoil from the greater Dublin area are being moved to SRFs in the hinterland of the city. This material is likely to be mainly comprised of the Dublin Boulder Clay (DBC), which is poorly understood in terms of its geochemistry and is anecdotally known to have anomalously high levels of some metals and metalloids. Given that the NSDB did not survey Dublin soils, the GALs suggested here do not take account of the DBC. It is recommended that a geochemical characterization of the DBC is carried out in support of further refinement of this project.